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G1U UR3136
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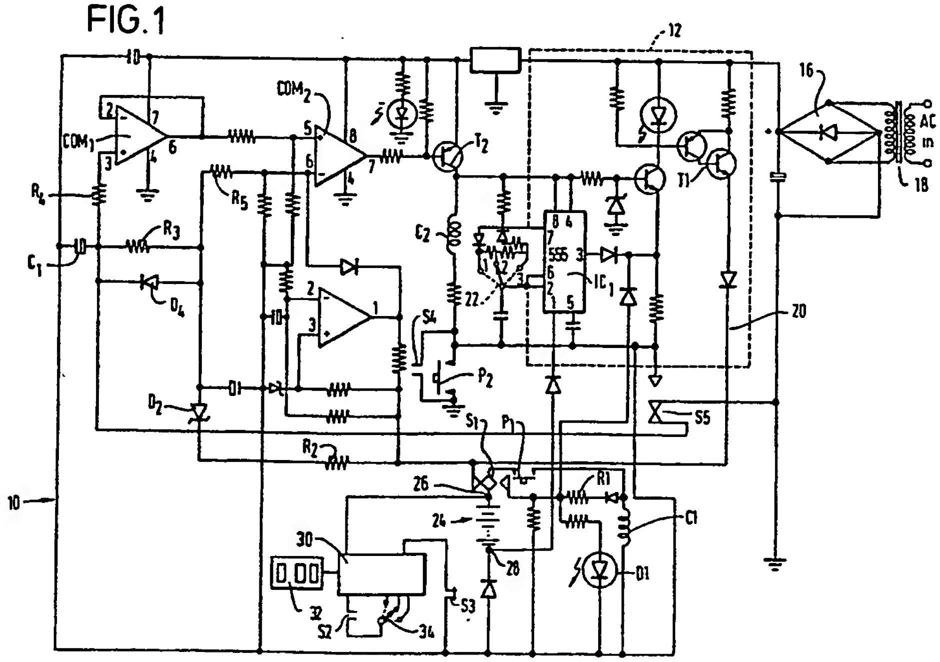
7/04 7/06 7/08 7/10 7/12

(54) **Battery charger**

(57) The charger has a timer 30 coupled to a display 32 to give an indication of the amount of charge added to the battery 24. The display may be calibrated to show the actual charge in mAH or may indicate the time for which the battery can be used in, eg., a mobile telephone. Operation of a switch P1 energises a relay coil C1 causing the battery 24 to be first discharged through a resistor R1 until the relay C1 drops out whereupon a relay coil C2 is energised resulting in pulse charging of the battery 24 via a transistor T1 and operation of the timer 30. A switch 22 can adjust the pulse width to change the charging rate and is ganged to a switch 34 which changes the dividing ratio of a divider in the timer 30. Coil C2 is deenergised to stop charging when circuit C1, COM 1, COM 2 detects that the battery voltage has started to decrease after reaching a peak. The battery may be charged without the initial discharge stage if switch P2 is operated instead of switch; the display 32 will then indicate the charge added rather than the actual charge state of the battery.

FIG.1



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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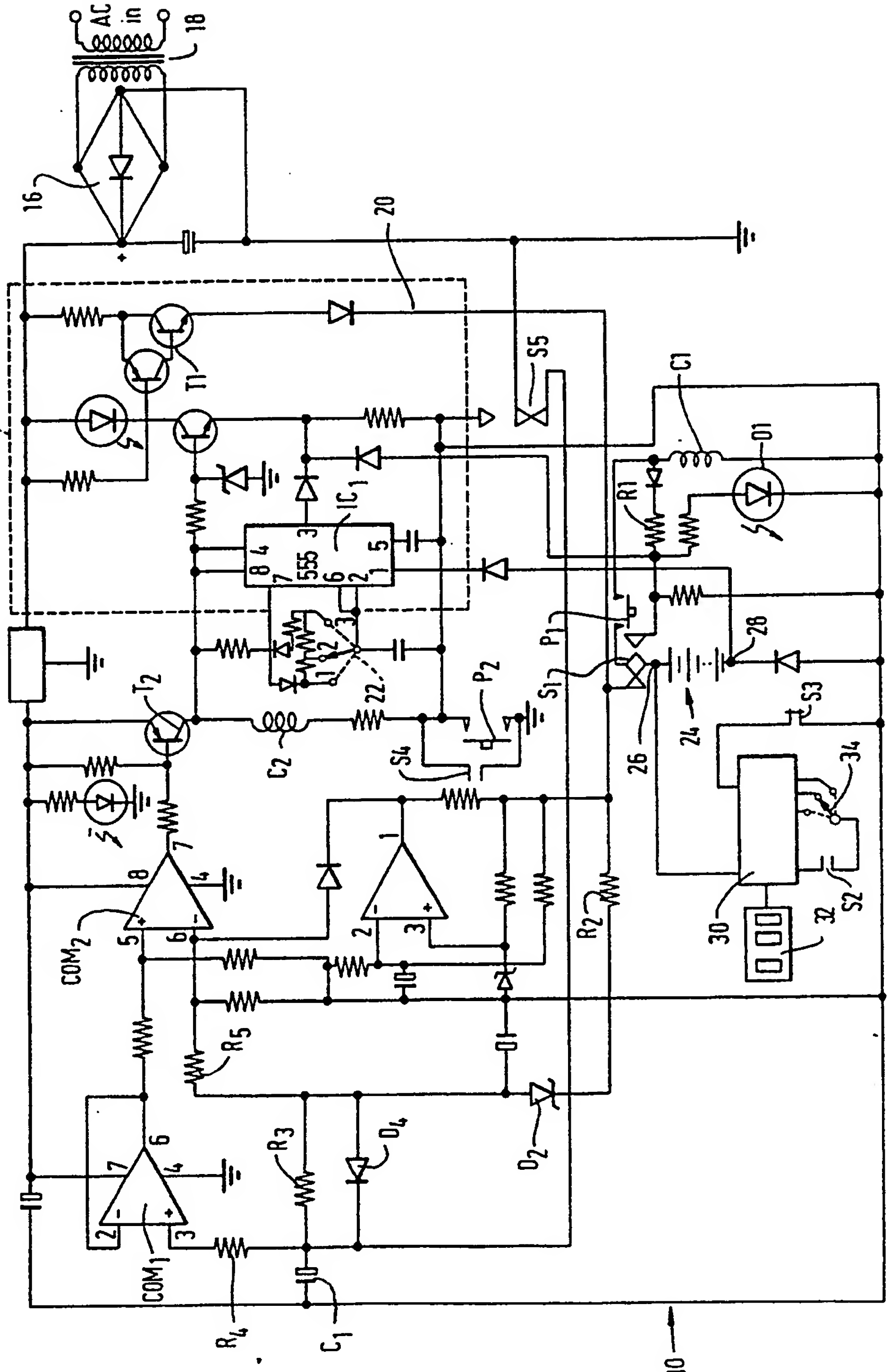
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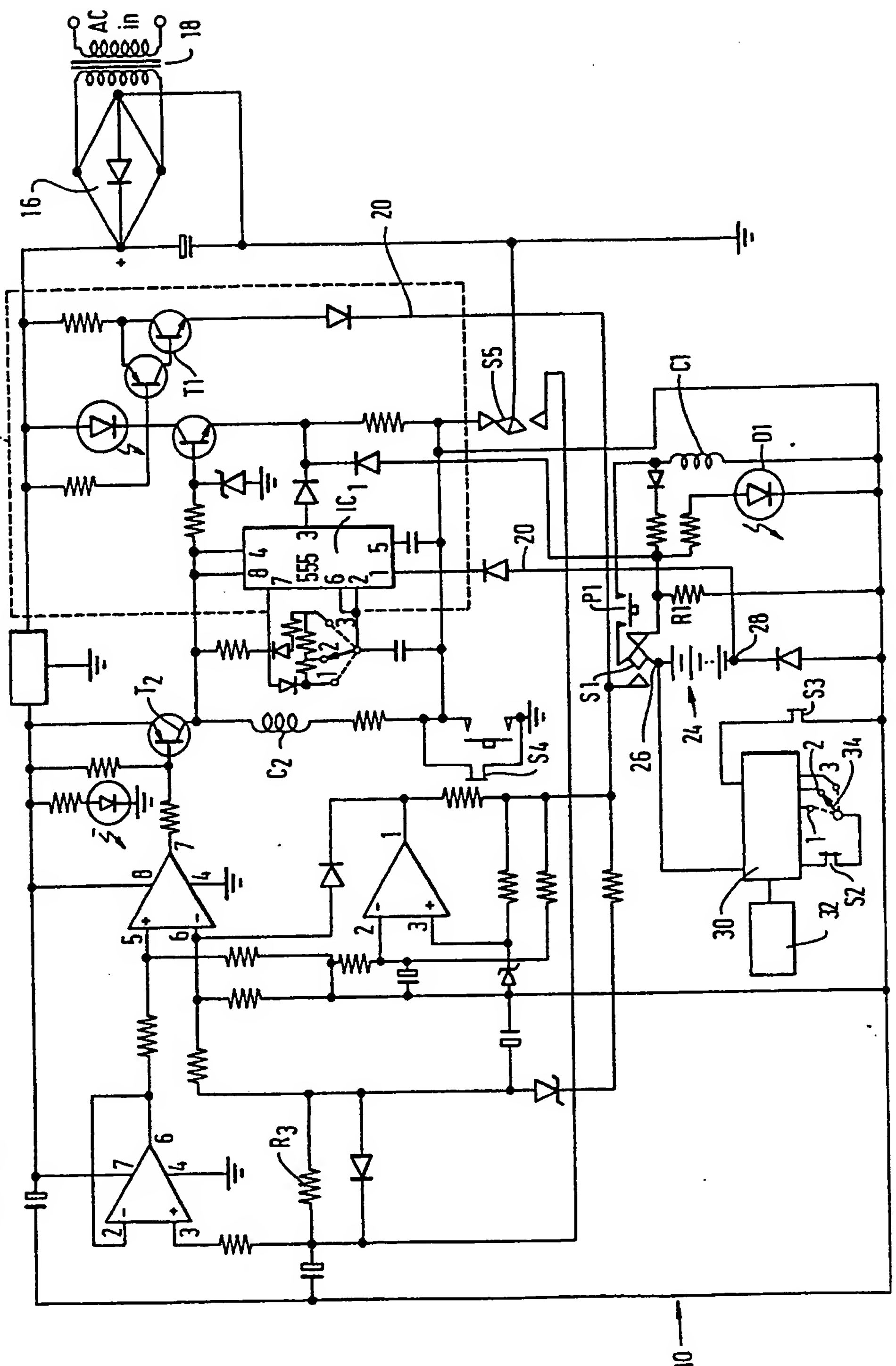
16
20
12
T1
IC1
555
S5
C1
D1
R1
P1
28
S1
26
24
S3
34
S2
32
30
22
P2
S4
T2
C2
COM2
R2
R5
D2
D4
R3
COM1
R4
C1
10

FIG.1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S5
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D1
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555
P1
R1
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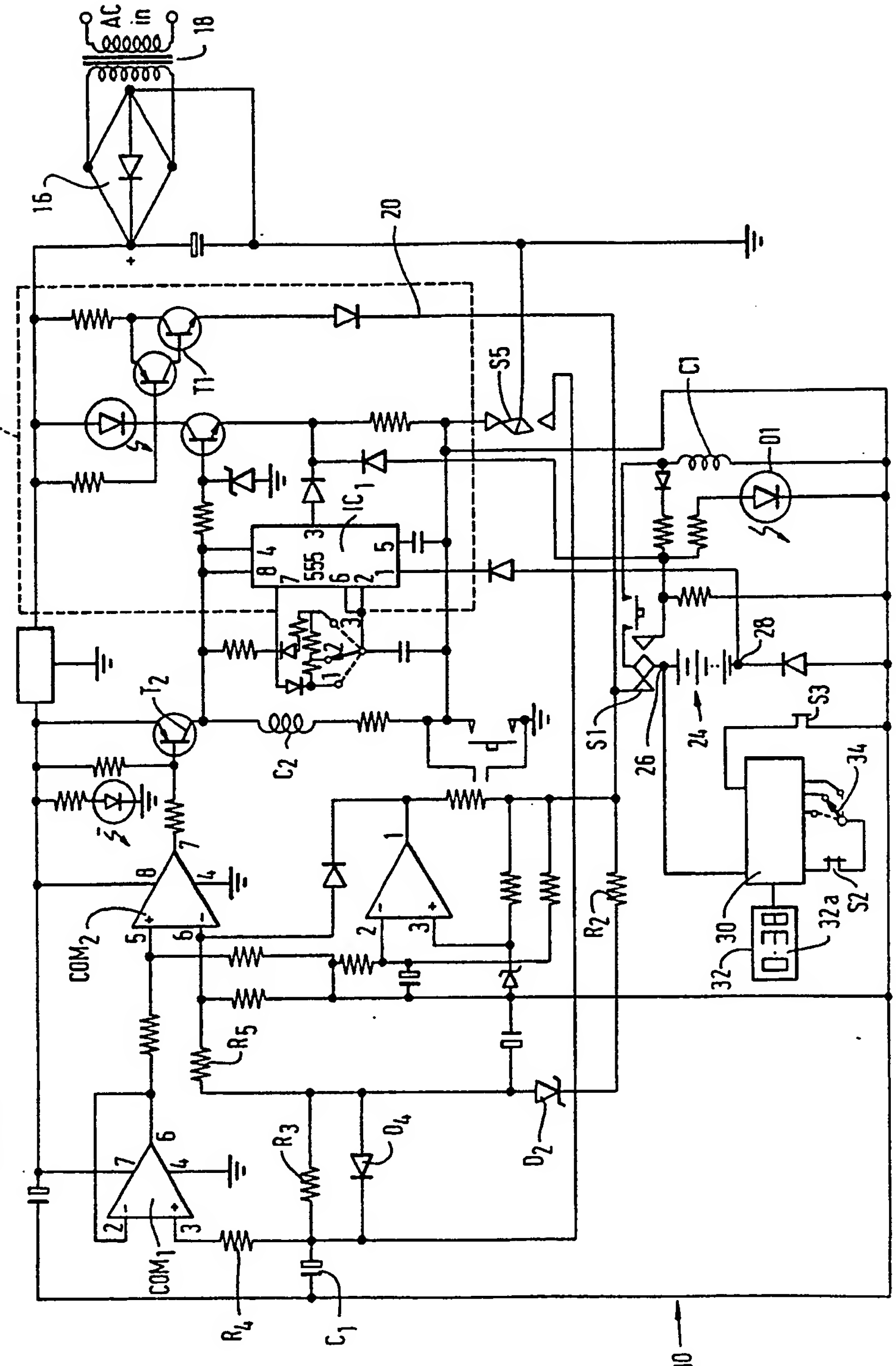
S4
R3
10

FIG.2

FIG. 3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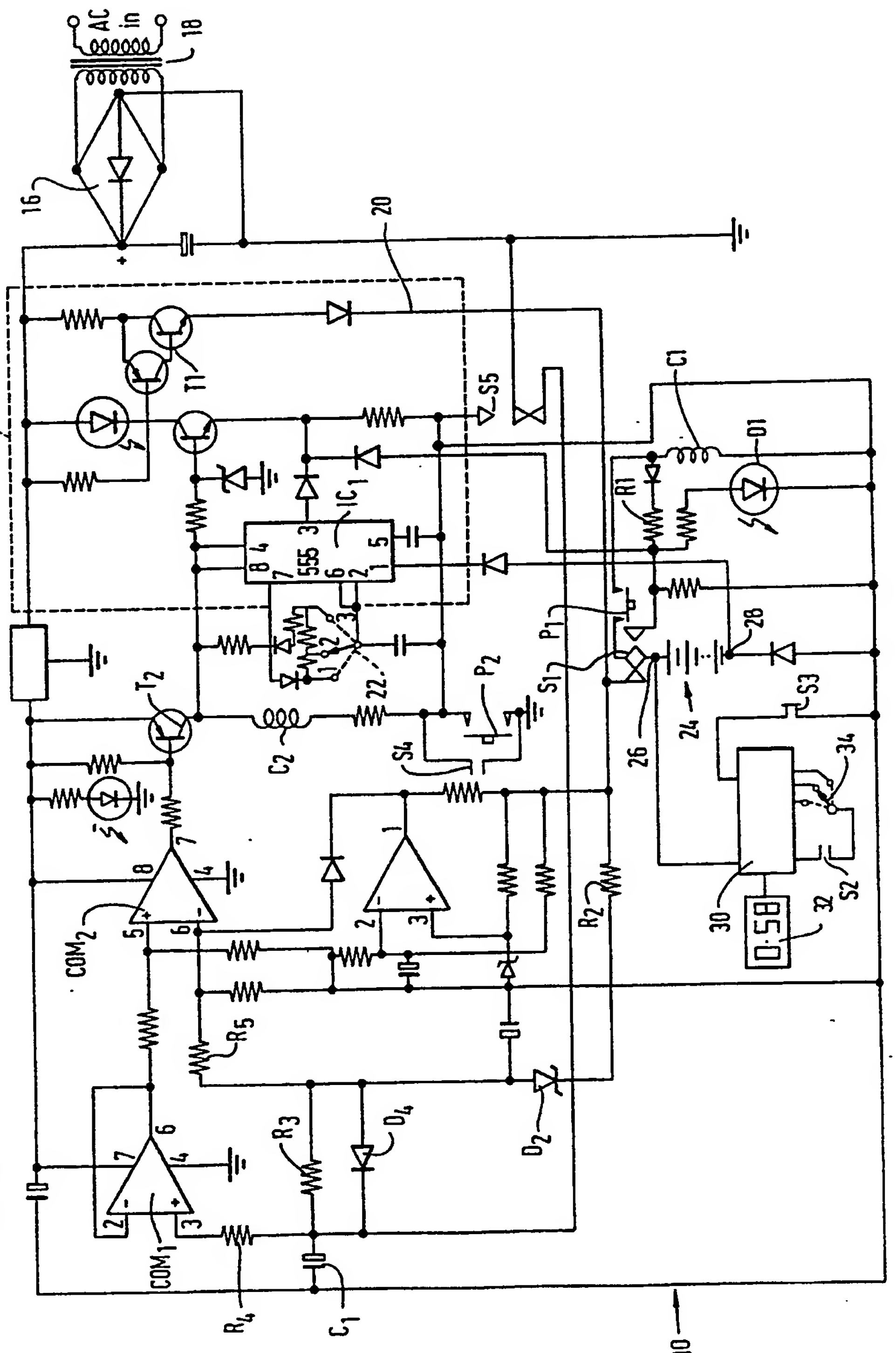
16
20
12
T1
S5
C1
D1
IC1
555
T2
C2
28
S3
S1
26
24
34
30
32
32a
S2
R2
COM2
R5
COM1
R3
D4
D2
R4
C1
10

FIG.4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22
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COM1
R4
C1
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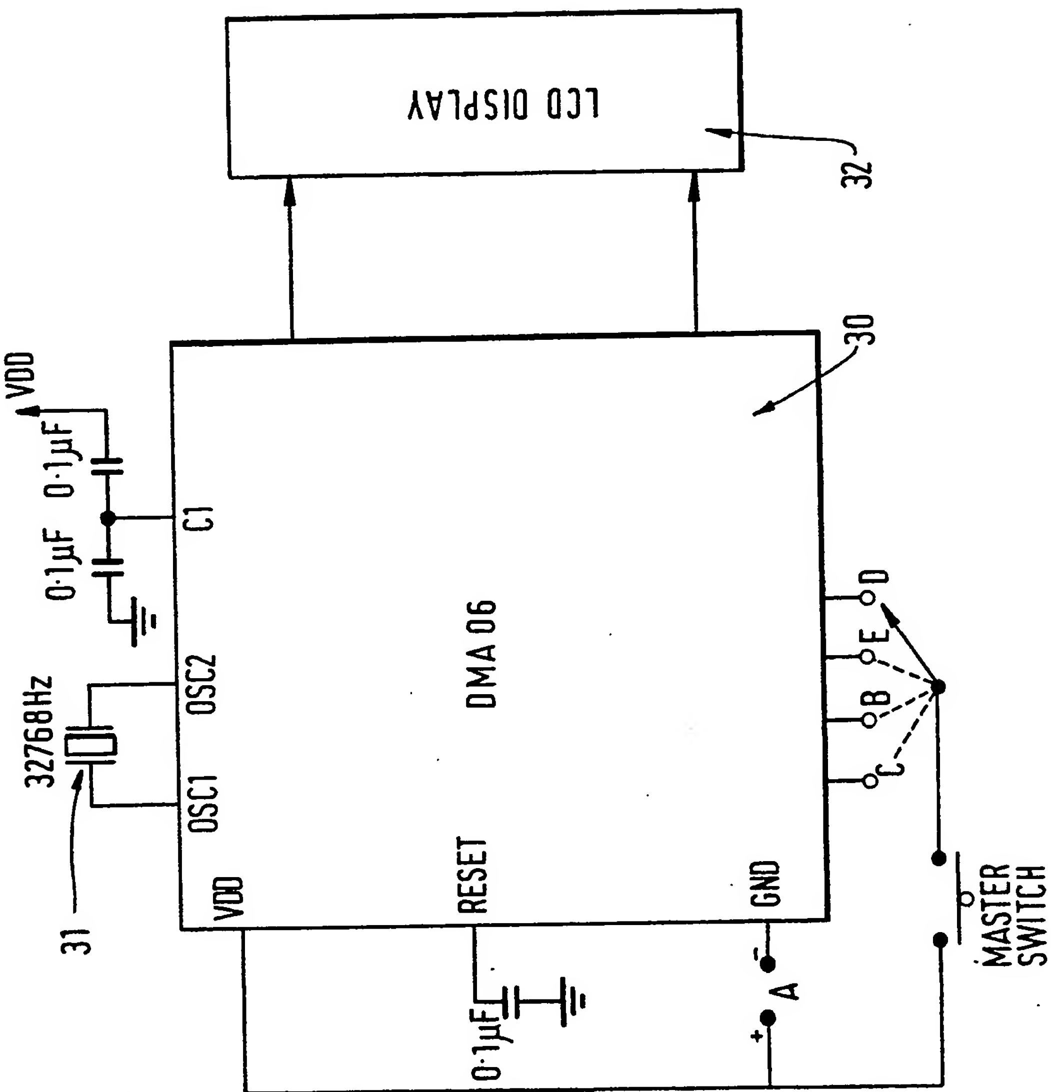
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32
30
DMA 06
VDD
0·1µF
0·1µF
C1
OSC2
OSC1
32768Hz
31
VDD
RESET
0·1µF
GND
+
A
–
C
B
E
D
MASTER SWITCH

FIG.5

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BATTERY CHARGER

This invention relates to a battery charger and it is particularly useful with rechargeable batteries of the type used to power mobile electronic equipment such as portable telephones. The invention has particular application to the recharging of Ni-Cd batteries.

Generally speaking, such battery chargers work by supplying a DC recharging voltage across the batteries at a potential higher than the potential remaining in the battery. This has the result of storing in the batteries a degree of charge. However it has not in the past been easy to determine when a battery is fully charged and generally a battery has been left on charge for a sufficient time to ensure that, even if it were fully discharged at the commencement of charging, it will after that time be fully charged. The disadvantage of this is that a battery may not be fully discharged and so this may result in a degree of overcharging which may damage the battery.

In general terms, it has been the practice to try and overcome this problem by first of all completely discharging any battery which is to be charged. Thus the battery is allowed to discharge slowly through a resistance and once the voltage level of the battery has

reduced below a preset figure corresponding to its being largely discharged, then the charging can commence. Provided one thereafter charges for a sufficient period but no more to ensure that the battery becomes fully charged at a particular charging rate, then one can ensure that such a battery will not be overcharged and will be fully charged if left to charge for the full period of time.

With items such as portable telephones however it may not be as simple as this in that in general a user will leave the battery for recharging whenever he has convenient access to a mains outlet and he is not using the telephone. He may however suddenly need to remove the telephone before the battery has become fully charged and he will not have any idea as to the remaining capacity of the battery if it has not been left for the full time to ensure a full charge.

Also the matter can be complicated by the fact that battery chargers often have a number of different charging rates and again the time for a full charge will depend upon the charging rate.

It is therefore an object to the invention to provide a battery charger which overcomes this problem.

According to the invention there is provided a battery charger which has means for providing a DC output from a mains AC input for recharging a storage battery, an electronic timer being powered

simultaneously with the charging of the battery, means for setting the timer to zero when the DC output is initially supplied, and a visible output display from the timer, whereby after a period of charging of the battery, the timer will have measured the time of charging of the battery and so can provide the user with an indication of the amount of charge stored in the recharged battery.

With such a battery charger therefore the display gives an indication of the extent of charge of the battery so even if the battery has to be removed from the charger before there has been time for a complete charge, the display will give an indication as to the minimum amount of charge in the battery. The output from the display will give the user, for example, the time for which he can use say a mobile telephone with the battery before it is liable to fail, or alternatively, the display can be calibrated to show the actual change in units such as mAH.

In a preferred embodiment the timer is powered by the battery and switch means are provided to isolate the battery from the timer until the battery is charged.

The timer may comprise a high frequency signal generator, divider means fed by the generator to reduce the frequency of the signal, and counter means for counting the reduced frequency to equate this with time, the display giving an indication of the count

corresponding to the time elapsed. Such an arrangement is well-known and comparable to that existing in a quartz oscillator controlled watch or clock. The output however provided to the display will give an indication of the extent of charge rather than a time as such.

The rate of charge to the battery can be adjustable and one can pre-select one of a number of different charging rates. In these circumstances the divider circuit means can be provided with adjusting means to vary the rate of division of the high frequency signal so that the display will give an equivalent charged capacity output which depends of course upon the time of charge and the rate of charge. Thus for example if one considers a standard rate of charge as requiring X hours to provide a fully charged state, then if one charges at the twice of the standard rate, then one only needs to charge for X/2 hours to provide the same extent of charge and so on.

The charging voltage applied to the battery can be a pulse output with a constant DC maximum value and the rate of charge can then be varied by varying the width of the pulses in such a pulse output.

As noted above it is undesirable that the battery be overcharged beyond its fully charged state. In practice it is known that if one monitors the voltage of a battery, particularly a Ni-Cd battery, whilst it is being charged, it will progressively reach a peak up to

the point where it is fully charged and then its potential will suddenly reduce. If one therefore plots a chart of the voltage during charge against time, one reaches a point at inflection at the fully charged state.

Therefore according to a preferred embodiment of the invention, comparator means are provided to monitor the voltage of those battery during charging and for stopping further charging and operation of the timer when the voltage reaches a peak.

Preferably the comparator means comprise a capacitor slowly charged through a high resistance by the battery under charge, and means for comparing the instantaneous output voltage from the battery against the output voltage of the capacitor, whereby when the battery voltages reach a peak the output from the capacitor will thereafter exceed the said instantaneous output, and means for detecting that situation and stopping further charging of the battery.

It is also preferred that switch means, eg, a solenoid operated relay, be provided which open and isolate the battery from the said DC output when further charging is to be stopped, those said switch means also preventing further operation of the timer, but allowing the display to show the final time by being powered by the charged battery.

Further as noted above it is desirable to fully discharge the battery before charging commences. This is to avoid "memory effect". Thus if a battery is charged and discharged repeatedly without a complete discharge say at least once a week, the capacity and power will gradually diminish. Therefore according to a preferred embodiment means are provided to discharge the battery to a preset low discharged voltage prior to charging, switch means being provided in series with the discharge of the battery to complete the discharge circuit, those switch means reverting to an open condition when the voltage across the battery reaches a preset low discharged valve.

Preferably those switch means comprise a relay, the coil of the relay being energised by the battery to hold the switch contacts of the relay in the closed position, those switch contacts being in series with the discharge of the battery, the coil allowing the opening of those switch contacts and its own de-energisation once the emf of the battery reaches the said preset low voltage which is insufficient to maintain its switch contacts closed.

A battery charger according to the invention will now be described, by way of an example, with reference to the accompanying drawings, in which:

Figure 1 is a circuit diagram showing the battery charger in its initial condition when a battery to be charged is inserted;

Figure 2 shows the circuit in the condition whilst the battery is discharged;

Figure 3 shows the circuit during the subsequent charging of the battery;

Figure 4 shows the circuit once the battery is fully charged; and

Figure 5 is a more detailed diagram of part of the circuit.

The battery charging circuit 10 shown in the drawings include a conventional pulse charging circuit 12. That circuit 12 is supplied with DC from a diode bridge 16 which is in turn powered by a step down transformer 18 from in an AC mains input. The charging output in the form of DC pulses is provided on a line 20, the pulses being controlled by a transistor T1. The on/off of this transistor is controlled by a chip IC1 which can be a conventional 555 chip. The charging rate, namely the width of the pulses supplied at the line 20, can be varied by means of a selector switch 22 which for example has three positions and depending upon the positioning of the switch 22, the width of the pulses can be selected and accordingly the charging rate.

A battery 24 to be charged is placed between contacts 26 and 28. In the initial position shown in Figure 1 the battery is isolated from the remainder of the circuit by the position of the switch contacts of a two position switch S1 and a push switch P1.

Connected across the battery is a timer circuit 30 with a display 32 in the form for example, of an LCD. The switch contacts of a switch S2 are normally open and therefore the timer does not count. However, the display 32 is powered from the battery but merely shows its initial zero display.

Initially the user will wish to discharge the battery and this is achieved by pressing the push button switch P1. This establishes a circuit powered by the battery 24 through a solenoid coil C1. The coil C1 controls switch contacts S1 and switch contacts S3 and S4 as will be described. As soon as current is established through the coil C1, this will move the switch contact S1 from its rest position shown in Figure 1 to the position shown in Figure 2 and will establish and continue the current through the coil C1 via a resistor R1. The push button switch P1 can now be released but the current will continue through the coil C1. To indicate a discharging condition a light emitting diode D1 will now be energised.

This condition is shown in Figure 2. In addition it will now be noted that the normally closed

switch contact S3 will have opened and the normally open switch contacts S4 will have closed, since they are both controlled by the energisation of the coil C1.

As a result of the closure of the contacts S4 the circuit through a coil C2 and a transistor T2 is now completed. The coil C2 can now become energised. Current will therefore pass through coil C2 and this can now activate switch contacts S2 and S5 which are part of a relay of which the coil C2 forms part.

Upon energisation of the coil C2, the normally open switch contacts S2 become closed. The timer 30 however will not be activated and will not count since it is now isolated by the now open switch contacts S3 controlled by the coil C1. The display 32 is not energised. In addition, the switch contacts S5 move from the rest position shown in Figure 1 to the position shown in Figure 2. This completes a circuit from the coil C2 to ground and by-passes the contacts S4.

The coil C1 continues to be energised by the battery 24 all the time that there is sufficient power in the battery. The battery therefore discharges via a resistor R1, eg of 8 ohms and 10 watt capacity, so that it will slowly discharge.

The circuit 10 during this discharging condition of the batteries is shown in Figure 2.

As the battery discharges its potential slowly drops but as it approaches the point of complete

discharge which for say a series of six battery cells with a nominal output voltage of 7.2 volts will drop to about 6 volts, the voltage suddenly drops. The arrangement of the coil C1 is such that once the potential across it drops below about 6 volts then current through it will be insufficient to energise it sufficiently to keep the switch contacts S1 to S4 in their activated condition. Therefore once the voltage across the battery 24 diminishes to about 6 volts, suddenly the energy passing through the coil C1 will be sufficient to retain the switch contacts S1, S3 and S4 in their active position and they will return to their rest position.

This means that the switch contact S1 returns to the position shown in Figure 1, the contacts S3 close, and the contacts S4 open. As a result the coil C1 is now isolated from the battery which therefore ceases to discharge.

The contacts S3 return to their normally closed position and so the counter 30 now becomes connected across the battery 24 and energised. Also the contacts S4 open but this does not affect the current passing through the coil C2 which remains energised since they are by-passed by the position of the switch contacts S5.

The circuit 10 is therefore now in the position shown in Figure 3.

DC charging pulses on the line 20 now charge the battery 24.

Also the counter 30 now works and the display 32 is energised to show an alpha-numeric output which is equivalent to time, namely the time of charging of the battery 24. The colon 32 on the display will flash and the display will have a numeric output, for example, Figure 3 shows the figure 38, corresponding to a use time of say 38 minutes if the battery 28 were then used in powering a standard piece of equipment such as a mobile telephone.

The counter 30 is shown in more detail in Figure 5. It includes a conventional quartz oscillator 31 with a number of divider circuits reducing the high frequency output from the oscillator and having an ultimate counter circuit counting the reduced frequency.

Ganged with the switch 22 is a three position switch 34. This controls the rate of division of the divider circuits according to the charging current. Thus for example if one has a charging current of unity which would say, complete a charge of the battery 24 within say 2 hours, one might be in say the position 2 of the switches 22 and 34. If one altered say to position 1, the charging rate might divide by 2 and therefore it would nominally take four hours to complete charge. Therefore the divider circuit needs to count half as fast so as to show the same degree of capacity

of charge on the display 32. In contrast if, for example, in the position 3, the charging rate is twice unity than clearly the divider circuits will need to eliminate one divide by two step so that the output counts up twice as quickly so as to show a full charge after 1 hour. Thus, irrespective of the charging rate, if the battery is left to charge fully, the output of the display 32 will be the same, eg. 2.00 hours.

The charging of the battery 24 will now continue and the emf of the battery will progressively increase. It is well known that during charging this emf increases up to a point where at a full charge the emf will then decrease. Arrangements are therefore made in the circuit 10 to detect this point of inflection.

The emf of the battery at the contact 26 passes through the switch contact S1, a resistor R2, and a diode D2 and a high resistance resistor R3 to a capacitor C1. This capacitor C1 will slowly therefore charge up and will follow the increase in charge on the battery 24. The resulting voltage on the capacitor C1 passes via a resistor R4 to a first comparator COM1 whose output passes to a pin 5 of a second comparator COM2. The instantaneous voltage of the battery at the terminal 26 also passes directly to the comparator COM2 on pin 6 via a resistor R5.

Therefore all the time that the voltage on the terminal 26 is slowly increasing, the voltage on pin 6

of COM2 will precede or be higher than the voltage on pin 5. The moment a point of inflection is reached, however, and the voltage on a point 26 starts to decrease then the voltage on pin 6 will immediately decrease. However the voltage on pin 5 will not decrease as rapidly since a diode D4 prevents reverse discharge of the capacitor C1 other than through the high resistance R3 and so now the voltage on pin 5 will be higher than the voltage on pin 6. As a result the comparator COM2 the output from the comparator COM2 inverts and turns "off". Once the output on pin 7 becomes "off", this renders transistor T2 non-conductive. This in turn stops current flow through the coil C2.

As a result of this further charging is stopped. Thus, once coil C2 becomes de-energised the switch contacts S2 and S5 associated with it now revert to their rest positions. Thus the contact S2 now opens so stopping the counter circuit 30 from counting, but the display 32 remains energised. Also the contact S5 changes. The circuit therefore is as shown in Figure 4. The oscillator and counter circuit 30 therefore cease to count. The total count however reached during the charge is still displayed as a final figure, for example 0.58 hours as shown by way of example in Figure 4. The colon of the display no longer flashes however. The output of the display shows the charged capacity in the

battery and so the user can observe this when he comes to remove the battery 24. When the battery is removed, the display ceases to be energised and the circuit 10 becomes the same as in Figure 1.

The circuit 10 can be operated in an alternative manner when the user knows there is not sufficient time for him to fully discharge the battery and then fully charge it. He may therefore want to give the battery a quick extra boost. Under these circumstances, he inserts the battery 24 and instead of pressing the push button P1 he presses the push button P2 which is in parallel with switch contacts S4. This has the effect of immediately energising the coil C2 and so commences the charging cycle as has been described above. It also starts the counter cycle of the counter circuit 30 and so that circuit 30 will show the time and extent of charge. The circuit will of course automatically de-energise itself and stop further charge after the battery reaches a fully charged state. The display 32 will not necessarily give an accurate reading. However the user will be able to know when he removes the battery 24, if the circuit has stopped operating, that a full charge has been achieved or, on the other hand if a full charge has not been achieved when he comes to remove the battery 24 he will at least be able to tell from the display 32 the amount of charge

which has been added and which will in effect represent the minimum charge on the battery.

CLAIMS:

1. A battery charger which has means for providing a DC output from a mains AC input for recharging a storage battery, an electronic timer being powered simultaneously with the charging of the battery, means for setting the timer to zero when the DC output is initially supplied, and a visible output display from the timer, whereby after a period of charging of the battery, the timer will have measured the time of charging of the battery and so can provide the user with an indication of the amount of charge stored in the recharged battery.

2. A battery charger as claimed in Claim 1 in which the timer is powered by the battery and switch means are provided to isolate the battery from the timer until the battery is charged.

3. A battery charger as claimed in Claim 1 or Claim 2 in which the timer comprises a high frequency signal generator, divider circuit means fed by the generator to reduce the frequency of the signal, and counter means for counting the reduced frequency to equate this with time, the display giving an indication of the count corresponding to time elapsed.

4. A battery charger as claimed in Claim 3 in which the high frequency signal generator is a crystal controlled oscillator.

5. A battery charger as claimed in Claim 3 or Claim 4 in which means are provided to preset and select a rate of charge for the battery, the divider circuit means being adjusted to alter the rate of division of the high frequency signal to give a corresponding equivalent charge capacity output to the display, so that the time displayed is equivalent to a time at a standard charge rate.

6. A battery charger as claimed in any preceding claim in which the means for providing the DC output provide a pulse output of constant DC maximum value.

7. A battery charger as claimed in Claim 6 in which means are provided to vary the charge rate of the battery by varying the width of the pulses of the pulse output.

8. A battery charger as claimed in any preceding claims in which comparator means are provided to monitor the voltage of the battery during charging and for stopping further charging and operation of the timer when the voltage reaches a peak.

9. A battery charger as claimed in Claim 8 in which comparator means comprise a capacitor slowly charged through a high resistance by the battery under charge, and means for comparing the instantaneous output voltage from the battery against the output voltage of the capacitor, whereby when the battery voltages reach a peak the output from the capacitor will exceed the said

instantaneous output, and means for detecting that situation and stopping further charging of the battery.

10. A battery charger as claimed in Claim 8 or Claim 9 further comprising switch means which open and isolate the battery from the said DC output when further charging is stopped, those said switch means also preventing further operation of the timer, but allowing the display to show the final time by being powered by the charged battery.

11. A battery charger as claimed in Claim 10 in which the switch means comprise a relay which is energised only whilst the DC output continues, the switch contacts of the relay comprising the switch means.

12. A battery charger as claimed in any preceding claim in which means are provided to discharge the battery to a preset low discharged voltage prior to charging, switch means being provided in series with the discharge of the battery to complete the discharge circuit, those switch means reverting to an open condition when the voltage across the battery reaches a preset low discharged valve.

13. A battery charger as claimed in Claim 12 in which those switch means comprise a relay, the coil of the relay being energised by the battery to hold switch contacts in series with the discharge of the battery in the closed position, the coil allowing the opening of

those switch contacts and its own de-energisation once the emf of the battery energising the coil reaches the said preset low voltage.

14. A battery charger as claimed in Claim 12 or Claim 13 in which switch means are provided to commence charging of the battery once the battery has discharged to the said preset low discharged voltage.

15. A battery charger substantially as herein described with reference to the accompanying drawings.

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